

1 **Glass like material with improved safety characteristics.**

2

3 The present invention relates to a glass-like material  
4 which has improved safety characteristics compared to  
5 ordinary glass.

6

7 In the present Application references to a "glass-like"  
8 material refer to a material having the following  
9 characteristics; clarity, brittleness, low strain to  
10 failure and rigidity.

11

12 Ordinary glass is used in a variety of everyday  
13 applications. For example it is known in the art to use  
14 glass as a protective covering over fire and other types  
15 of emergency alarms, emergency door releases, emergency  
16 stop buttons on public transport, fire extinguishers,  
17 fire axes and the like. As glass is transparent persons  
18 can quickly and easily identify the presence of the alarm  
19 or apparatus in the retaining box. If required, the  
20 glass can be broken in order to access the alarm or  
21 device.

22

23 However an inherent problem lies in the manner in which  
24 the glass can be broken. Often a subsidiary device such

1 as a hammer is supplied with, or near to, the alarm or  
2 apparatus, and can be used to break the glass. However,  
3 in the event that this device is missing or cannot be  
4 located in an emergency situation it will be necessary  
5 for the person who wishes to access the apparatus or  
6 alarm to break the glass by some other means. In the  
7 event of an emergency situation the person may use, for  
8 example, a hand or elbow for this purpose, and may, as a  
9 result, sustain injuries from breaking the glass.

10 Breakage of glass results in the production of sharp  
11 glass fragments and splinters, which can cause injury to  
12 the user or other persons in the proximity of the alarm  
13 or apparatus. In addition the potential risk of injury  
14 from breaking the glass may cause hesitation on the part  
15 of the person who wishes to access the alarm or  
16 apparatus, having dangerous consequences.

17

18 The glass may also be broken by malicious or accidental  
19 damage. Whilst the glass fragments can be removed and  
20 the retaining glass replaced, there is an interim risk of  
21 injury to persons coming into contact with the broken  
22 fragments.

23

24 Considerable research has been conducted to find  
25 materials which can be used in Applications similar to  
26 glass but which minimise the risk of damage to persons in  
27 the instance of the material being broken either  
28 intentionally or accidentally. Safety glass i.e.  
29 toughened glass, materials are well known in the art and  
30 have numerous applications and uses. Most have enhanced  
31 safety by virtue of being reinforced in strength, such  
32 that they have a higher stress to failure than glass; in  
33 other words a greater force is needed to shatter or break  
34 them than would be required with ordinary glass. Uses

1 vary from windows and doors on automobiles and public  
2 transport, to domestic uses such as shower enclosures and  
3 room partitions. Whilst in many instances these have  
4 greatly increased safety, they are of limited use in  
5 Applications where it is actually desirable for the glass  
6 to be broken, i.e. when used on retaining boxes of  
7 emergency apparatus and alarms, because of their enhanced  
8 strength and resistance to force.

9

10 For example the polymeric materials Perspex™ and  
11 Plexiglas™, are transparent like glass, and do not pose  
12 the same risk of injury when broken. However, these  
13 materials can be harder to break than glass and can still  
14 produce sharp fragments when broken.

15

16 In addition, the containers in which alcoholic drinks,  
17 carbonated soft drinks and oxygen sensitive juices are  
18 sold are also traditionally manufactured from glass.  
19 Glass bottles are well received by consumers as they  
20 impart the impression of a high quality product and have  
21 "chink factor". Nevertheless, the use of bottles is  
22 inherently dangerous, as glass is easily broken. It will  
23 be appreciated that this is a particular problem in bars,  
24 pubs and nightclubs, where accidental breakage of glass  
25 bottles, is a potential health risk.

26

27 Glass bottles are also disliked as they can be used  
28 deliberately, as weapons, to inflict damage on other  
29 persons. In fact, safety regulators have actively  
30 encouraged drinks manufacturers, as well as  
31 establishments which serve drinks and alcohol, to use  
32 bottles and glasses made from non-dangerous materials, in  
33 order to reduce the number of serious injuries caused by  
34 glass and bottle attacks.

1  
2 In recent years there has been a move towards providing  
3 bottles manufactured from materials which are not as  
4 dangerous as glass. It is estimated that packaged beer  
5 production world wide in 1996 was 106.6 billion litres,  
6 requiring 186.2 billion bottles and 73.7 billion cans.  
7 The beer bottle market was forecasted to grow at an  
8 annual rate of three percent through 2001 to 216 billion  
9 units. Most bottle production makes use of glass with  
10 only 0.1 billion plastic bottles being utilised in 1996.  
11 However due to the push towards increased safety it is  
12 estimated that the demand for plastic bottles is forecast  
13 to reach 2.5 billion by 2006.

14  
15 The focus on safer bottles is particularly important with  
16 respect to alcoholic drinks, which are consumed in bars  
17 and nightclubs. PET, poly(ethylene terephthalate), a  
18 plastic which can be readily manufactured into bottles,  
19 and which does not break as readily as glass, has already  
20 been used for this purpose.

21  
22 However the use of PET poses its own problems to the  
23 industry. PET is a relatively expensive material and not  
24 cheap to process which makes it a less popular option for  
25 drinks manufacturers. In addition, there is a general  
26 consensus that plastic bottles are not as well received  
27 by the public as they feel cheaper and do not have the  
28 same high quality feel as glass.

29  
30 It is therefore an object of at least one aspect of the  
31 present invention to provide a material which resembles  
32 glass, but which has improved safety characteristics when  
33 compared to ordinary glass.

34

1 It is also an object of at least one aspect of the  
2 present invention to overcome the problems that are  
3 described above with reference to existing glass and  
4 plastic bottles.

5  
6 According to a first aspect of the present invention  
7 there is provided a material which shatters, when broken,  
8 into fragments which do not cut, puncture or otherwise  
9 damage human skin or tissue, wherein the material is  
10 comprised of an amorphous thermoplastic polymer and one  
11 or more low molecular weight resins.

12  
13 Preferably the material is comprised of a simple mixture  
14 of amorphous thermoplastic polymer and one or more low  
15 molecular weight resins.

16  
17 Preferably the amorphous thermoplastic polymer is chosen  
18 from the group consisting of polystyrene (PS), polymethyl  
19 methacrylate (PMAA), styrene-acrylonitrile copolymer  
20 (SAN), linear polyesters and co-polyesters and  
21 polycarbonate (PC).

22  
23 The one or more low molecular weight resins chosen will  
24 be completely compatible with the chosen polymer. For  
25 example in the case of polystyrene the low molecular  
26 weight resin is typically C9 aromatic hydrocarbon resin.

27  
28 Preferably the material has a tensile stress limit of  
29 between 11 and 60 Nmm<sup>-2</sup>.

30  
31 Preferably the low molecular weight resin will have a Mn  
32 (number average molecular weight) such that it has less  
33 than 500 repeating units, and preferably less than 50  
34 repeating units.

1

2 The material may be manufactured in sheet form.

3

4 According to a second aspect of the present invention  
5 there is provided a polymeric blend comprising a polymer  
6 selected from the group consisting of: polystyrene, (PS),  
7 polymethyl methacrylate (PMAA), styrene-acrylonitrile  
8 copolymer (SAN), linear polyesters and co-polyesters and  
9 polycarbonate (PC) and one or more low molecular weight  
10 resins.

11

12 The one or more low molecular weight resins chosen will  
13 be completely compatible with the chosen polymer. For  
14 example in the case of polystyrene the low molecular  
15 weight resin is typically C9 aromatic hydrocarbon resin.

16

17 Preferably the one or more low molecular weight resins  
18 have a Mn (number average molecular weight) such that it  
19 has less than 500 repeating units, and preferably less  
20 than 50 repeating units.

21

22 Preferably the one or more low molecular weight resins  
23 are hydrocarbon resins.

24

25 Preferably the one or more low molecular weight resins  
26 are aromatic hydrocarbon resins.

27

28 The polymeric blend may be manufactured in sheet form.

29

30 According to a third aspect of the present invention  
31 there is provided a material which shatters, when broken,  
32 into fragments which do not cut, puncture or damage human  
33 skin or tissue, the material being comprised of  
34 polystyrene and one or more low molecular weight resins.

1  
2 Preferably the material is comprised of a simple mixture  
3 of polystyrene and one or more low molecular weight  
4 resins.  
5  
6 Preferably the one or more low molecular weight resins  
7 are hydrocarbon resins.  
8  
9 Preferably the one or more low molecular weight resins  
10 are aromatic hydrocarbon resins.  
11  
12 Most preferably the one or more low molecular weight  
13 hydrocarbon resins are C9 aromatic hydrocarbon resins.  
14  
15 Preferably the one or more low molecular weight resins  
16 are, or are derived from, alpha methyl styrene.  
17  
18 Preferably the one or more low molecular weight  
19 hydrocarbon resins are selected from a group consisting  
20 of; Norsolene™, Kristalex™, Plastolyn™ Endex™,  
21 Piccotex™, Piccolastic™, Sukorez™ or Arkon™.  
22  
23 Most preferably the one or more low molecular weight  
24 hydrocarbon resins are selected from a group consisting  
25 of; Norsolene W90™, Norsolene W100™, Norsolene W110™,  
26 Kristalex F85™, Kristalex F100™, Kristalex F115™,  
27 Plastolyn 240™, Plastolyn 290™, Endex 155™,  
28 Piccolastic D125™, Sukorez 100™, Sukorez 120™, Arkon  
29 P100™, Arkon P125™, Arkon P140™, Piccotex 75™,  
30 Piccotex 100™ or Piccotex 120™.  
31  
32 Preferably the one or more low molecular weight resins  
33 will have a Mn (number average molecular weight) such

1 that it has less than 500 repeating units, and preferably  
2 less than 50 repeating units.

3

4 Preferably the material has a tensile stress limit  
5 between 11 and 60 Nmm<sup>-2</sup>.

6

7 Optionally the material may also include UV inhibitors,  
8 antioxidants, flow modifiers, fire retarding agents,  
9 colour pigments and brighteners as known in the art.

10

11 The material may be manufactured in sheet form.

12

13 According to a fourth aspect of the present invention  
14 there is provided a method of manufacturing a material  
15 which shatters, when broken, into fragments which do not  
16 cut, puncture or damage human skin or tissue, the method  
17 comprising the step of mixing an amorphous thermoplastic  
18 polymer and one or more low molecular weight resins.

19

20 Preferably the amorphous thermoplastic polymer is chosen  
21 from the group consisting of polystyrene (PS), polymethyl  
22 methacrylate (PMAA), styrene-acrylonitrile copolymer  
23 (SAN), linear polyesters and co-polyesters and  
24 polycarbonate (PC).

25

26 Preferably the one or more low molecular weight resins  
27 are completely compatible with the chosen polymer. For  
28 example in the case of polystyrene preferably the chosen  
29 low molecular weight resin is C9 aromatic hydrocarbon  
30 resin.

31

32 Preferably the one or more low molecular weight resins  
33 are hydrocarbon resins.

34



1 Preferably the one or more low molecular weight resins  
2 are aromatic hydrocarbon resins.

3

4 Preferably the low molecular weight resin will have a  $M_n$   
5 (number average molecular weight) such that it has less  
6 than 500 repeating units, and preferably less than 50  
7 repeating units.

8

9 Preferably as the polystyrene is mixed with the one or  
10 more low molecular weight hydrocarbon resins, the glass  
11 transition temperature ( $T_g$ ) of the material is elevated.  
12 Typically the  $T_g$  is elevated to 5-10 degrees C higher  
13 than the base polymer.

14

15 According to a fifth aspect of the present invention  
16 there is provided a method of manufacturing a material  
17 which shatters, when broken, into fragments which do not  
18 cut, puncture or damage human skin or tissue, the method  
19 comprising the step of mixing polystyrene and one or more  
20 low molecular weight hydrocarbon resins.

21

22 Preferably the one or more low molecular weight resins  
23 are hydrocarbon resins.

24

25 Preferably the one or more low molecular weight resins  
26 are aromatic hydrocarbon resins.

27

28 Most preferably the one or more low molecular weight  
29 hydrocarbon resins are C<sub>9</sub> aromatic hydrocarbon resins.

30

31 Preferably the one or more low molecular weight resins  
32 are, or are derived from, alpha methyl styrene.

33

1 Preferably the one or more low molecular weight  
2 hydrocarbon resins are selected from a group consisting  
3 of; Norsolene<sup>TM</sup>, Kristalex<sup>TM</sup>, Plastolyn<sup>TM</sup> Endex<sup>TM</sup>,  
4 Piccotex<sup>TM</sup>, Piccolastic<sup>TM</sup>, Sukorez<sup>TM</sup> or Arkon<sup>TM</sup>.

5  
6 Most preferably the one or more low molecular weight  
7 hydrocarbon resins are selected from a group consisting  
8 of; Norsolene W90<sup>TM</sup>, Norsolene W100<sup>TM</sup>, Norsolene W110<sup>TM</sup>,  
9 Kristalex F85<sup>TM</sup>, Kristalex F100<sup>TM</sup>, Kristalex F115<sup>TM</sup>,  
10 Plastolyn 240<sup>TM</sup>, Plastolyn 290<sup>TM</sup>, Endex 155<sup>TM</sup>,  
11 Piccolastic D125<sup>TM</sup>, Sukorez 100<sup>TM</sup>, Sukorez 120<sup>TM</sup>, Arkon  
12 P100<sup>TM</sup>, Arkon P125<sup>TM</sup>, Arkon P140<sup>TM</sup>, Piccotex 75<sup>TM</sup>,  
13 Piccotex 100<sup>TM</sup> or Piccotex 120<sup>TM</sup>.

14  
15 Preferably the low molecular weight resin will have a Mn  
16 (number average molecular weight) such that it has less  
17 than 500 repeating units, and preferably less than 50  
18 repeating units.

19  
20 The method may comprise the optional step of adding an  
21 additive selected from the group consisting of UV  
22 inhibitors, antioxidants, flow modifiers, fire retarding  
23 agents, colour pigments and brighteners as known in the  
24 art.

25  
26 Preferably as the polystyrene is mixed with the one or  
27 more low molecular weight hydrocarbon resins, the glass  
28 transition temperature ( $T_g$ ) of the material is elevated.  
29 Typically the  $T_g$  is elevated to 5-10 degrees C higher  
30 than the base polymer.

31  
32 According to a sixth aspect of the present invention,  
33 there is provided a container manufactured from a  
34 material that shatters when broken into fragments which

1 do not cut, puncture or otherwise damage human skin or  
2 tissue.

3

4 The container may be a bottle, glass, tumbler, or the  
5 like.

6

7 Preferably the material is comprised of an amorphous  
8 thermoplastic polymer and one or more low molecular  
9 weight resins.

10

11 Preferably the amorphous thermoplastic polymer is chosen  
12 from the group consisting of: polystyrene (PS), styrene-  
13 acrylonitrile co-polymer (SAN), linear polyesters and co-  
14 polyesters polycarbonate (PC).

15

16 Preferably the one or more low molecular weight resins  
17 are hydrocarbon resins.

18

19 Preferably the one or more low molecular weight resins  
20 are aromatic hydrocarbon resins

21

22 The one or more low molecular weight resins chosen will  
23 be completely compatible with the chosen polymer. For  
24 example, in the case of polystyrene, the low molecular  
25 weight resin will typically be C9 aromatic hydrocarbon  
26 resin.

27

28 Preferably the material has a tensile stress limit  
29 between 11 and 60 Nmm<sup>-2</sup>.

30

31 Preferably the one or more low molecular weight  
32 hydrocarbon resins are selected from a group consisting  
33 of: Norsolene™, Krystalex™, Plastolyn™, Endex™,  
34 Piccotex™, Piccolastic™, Sukorez™, Arkon™

1  
2 Most preferably the one or more low molecular weight  
3 hydrocarbon resins are selected from a group consisting  
4 of; Norsolene W90<sup>TM</sup>, Norsolene W100<sup>TM</sup>, Norsolene W110<sup>TM</sup>,  
5 Kristalex F85<sup>TM</sup>, Kristalex F100<sup>TM</sup>, Kristalex F115<sup>TM</sup>,  
6 Plastolyn 240<sup>TM</sup>, Plastolyn 290<sup>TM</sup>, Endex 155<sup>TM</sup>,  
7 Piccolastic D125<sup>TM</sup>, Sukorez 100<sup>TM</sup>, Sukorez 120<sup>TM</sup>, Arkon  
8 P100<sup>TM</sup>, Arkon P125<sup>TM</sup>, Arkon P140<sup>TM</sup>, Piccotex 75<sup>TM</sup>,  
9 Piccotex 100<sup>TM</sup> or Piccotex 120<sup>TM</sup>.

10

11 Preferably the low molecular weight resin will have a  
12  $\overline{M}_n$  (number average molecular weight) such that it has  
13 less than 500 repeating units, and preferably less than  
14 50 repeating units.

15

16 The container may be manufactured from the material using  
17 injection blow moulding and/or injection stretch blow  
18 moulding techniques.

19

20 Alternatively, the container may be manufactured from the  
21 material using extrusion blow moulding.

22

23 Optionally the material of the container may also  
24 comprise a oxygen barrier. The material of the container  
25 may also comprise oxygen scavengers.

26

27 The barrier included in the material of the container may  
28 be selected from the group consisting of: acrylonitrile-  
29 methyl acrylate copolymer, ethylene vinyl alcohol (EVOH)  
30 or nylon MXD6.

31

32 Preferably the barrier is Barex<sup>TM</sup>. Most preferably the  
33 barrier is Barex<sup>TM</sup> 210 or Barex<sup>TM</sup> 218.

34

1 In the embodiment where nylon MXD6 is used as a barrier,  
2 the oxygen scavenger may be X-312. Amosorb 3000, or a  
3 scavenger of MXD6 with metal catalysed oxygen reduction  
4 chemistry may also be used.  
5  
6 The barrier may be overmoulded or sprayed onto the  
7 container or alternatively may be included in the  
8 material of the container, using co-injection techniques.  
9  
10 The container may also have an inorganic coating. This  
11 may be a thin layer of amorphous carbon. The inorganic  
12 coating may be applied to the inside surface of the  
13 container. Typically the inorganic coating will be  
14 applied in a layer of 100 to 200nm thickness. The layer  
15 may be applied by spraying.  
16  
17 The container may also have an external organic coating.  
18 The external organic coating may be PVDC or a two  
19 component epoxyamine.  
20  
21 The container may be manufactured from multiple layers of  
22 the material. Two or more layers of the container may be  
23 combined to act as an improved oxygen barrier.  
24  
25 Optionally the material of the container may also include  
26 UV inhibitors, antioxidants, flow modifiers, colour  
27 pigments and brighteners as known in the art.  
28  
29 Preferably as the amorphous thermoplastic polymer is  
30 mixed with the one or more low molecular weight  
31 hydrocarbons, the glass transition temperature is  
32 elevated. Preferably the material of the container has a  
33 glass transition temperature of above 80°C.  
34

1 The material herein described can be used as a substitute  
 2 for ordinary glass. The material is glass-like in  
 3 character having clarity, brittleness, low strain to  
 4 failure and rigidity. The material has a variety of uses  
 5 including application as enclosures and boxes to house  
 6 emergency equipment e.g. keys, first aid boxes, fire  
 7 extinguisher, window hammers, emergency stop buttons,  
 8 emergency kick out panels and alarms, as well as use in  
 9 access panels, windows and doors. It should be  
 10 recognised that the abovedescribed uses are by way of  
 11 example only and are not intended to limit the manner in  
 12 which the material is used. The material can be  
 13 manufactured in sheet form, by extrusion, and moulded  
 14 into any shape by injection moulding or other standard  
 15 melt processes.

16

17 Table 1 shows the stress-strain behaviour of the material  
 18 in comparison to other polystyrene materials. Figure 1  
 19 shows this information in the form of a graph.

20

Table : Comparison of Properties of Safeglass™ to Polystyrenes.						
Polymer Type:	Modulus / GPa	Yield stress / MPa	Yield strain / %	Stress at break / MPa	Strain at break / %	Vicat softening temperature
Polystyrene (i.e. "crystal" or GPPS)	3.0 - 3.2	Brittle - no yield		4 - 75	2	82 - 98
Toughened polystyrene (e.g. HIPS)	1.6 - 2.4	18 - 38	1.5	< yield	15 - >50	76 - 95
Safeglass™	3.1 - 3.4	Brittle - no yield		8 - 40	1 - 2	95 - 104

21

22 N.B. Safeglass™ materials are slightly more rigid and  
 23 certainly more brittle than conventional  
 24 "crystal" polystyrene. Modified polystyrenes are  
 25 invariably less rigid and tougher materials as a result  
 26 of blending with a rubbery (low  $T_g$ ) additive. This also  
 27 results in a lowering of the Glass Transition Temperature

1 (T<sub>g</sub>) as witnessed by the reduction in the Vicat Softening  
2 Temperature. The reverse is true of Safeglass™ materials  
3 which show no such decrease in T<sub>g</sub>, indeed it can be  
4 higher than the critical temperature.

5

6 The material is fundamentally a blend of a rigid and  
7 normally brittle amorphous thermoplastic with a glass  
8 transition temperature T<sub>g</sub> at least 5° C above ambient and  
9 one or more compatible low molecular weight resins.

10

11 An example embodiment will now be described by way of  
12 example only.

13

14 A rigid and normally brittle amorphous thermoplastic  
15 polymer is blended with one or more low molecular weight  
16 resins which have a Mn (number average molecular weight)  
17 such that the resin has less than 500 repeating units,  
18 preferably less than 50 repeating units. The one or more  
19 low molecular weight resins have a weight average  
20 molecular weight of 6050 or below.

21

22 The material is manufactured by mixing or blending a  
23 clear polymer with one or more low molecular weight  
24 hydrocarbon resins. The polymer is an amorphous  
25 thermoplastic and can be chosen from the group of  
26 polystyrene, (PS), polymethyl methacrylate (PMAA),  
27 styrene-acrylonitrile copolymer (SAN), linear polyesters  
28 and co-polyesters and polycarbonate (PC). It is important  
29 that the low molecular weight resin is completely  
30 compatible with the chosen polymer. For example in the  
31 case of polystyrene it is C9 aromatic hydrocarbon resin.

32

33 In the herein described embodiment polystyrene is used.

34

1 The one or more low molecular weight resins which are  
2 mixed with the polystyrene are aromatic hydrocarbon  
3 resins and typically C9 aromatic hydrocarbon resins.  
4 The one or more resins are typically alpha methyl styrene  
5 or vinyl toluene or derivatives thereof. These are  
6 selected from the following group: Norsolene W90<sup>TM</sup>,  
7 Norsolene W100<sup>TM</sup>, Norsolene W110<sup>TM</sup>, Kristalex F85<sup>TM</sup>,  
8 Kristalex F100<sup>TM</sup>, Kristalex F115<sup>TM</sup>, Plastolyn 240<sup>TM</sup>,  
9 Plastolyn 290<sup>TM</sup>, Endex 155<sup>TM</sup>, Piccolastic D125<sup>TM</sup>, Sukorez  
10 100<sup>TM</sup>, Sukorez 120<sup>TM</sup>, Arkon P100<sup>TM</sup>, Arkon P125<sup>TM</sup>, Arkon  
11 P140<sup>TM</sup>, Piccotex 75<sup>TM</sup>, Piccotex 100<sup>TM</sup> or Piccotex 120<sup>TM</sup>.

12  
13 It has been discovered that by blending polystyrene with  
14 one or more of the abovementioned low molecular weight  
15 hydrocarbon resins, a hard, rigid material is formed  
16 which has the appearance and feel of glass, but which is  
17 extremely brittle and has low strain to failure. The  
18 material also has the inherent advantage that when  
19 broken, unlike glass, the material breaks into fragments  
20 which are not sharp and do not injure skin or tissue. The  
21 material is, by design, manufactured to break between 11  
22 and 60 Nmm<sup>-2</sup>. Therefore the material, when provided as a  
23 substitute to glass, for example in retaining boxes for  
24 emergency devices and alarms, can easily be broken by a  
25 human hand, fist, elbow, foot or the like and  
26 advantageously shatters into fragments or pieces which  
27 are not sharp and are not capable of cutting or  
28 puncturing human skin. Due to the inherent advantages of  
29 the material it is envisaged that it may have a variety  
30 of other uses, for example it may have application in  
31 novelty toys, such as stress relief toys, or have uses in  
32 "stunt" apparatus in, for example, theatres, shows or on  
33 film sets.

34



1 The material is manufactured by conventional melt  
2 compounding techniques. As the polystyrene is mixed with  
3 the one or more low molecular weight hydrocarbon resins,  
4 the glass transition temperature ( $T_g$ ) of the material is  
5 elevated as the low molecular weight resin does not have  
6 a plasticising effect, the opposite effect is seen as the  
7 glass transition temperature of the material is elevated.

8  
9 The material is generally transparent or clear, however  
10 dyes may be added to change the appearance of the  
11 material.

12  
13 Low molecular weight in resins is a function of the  
14 length of the chains in the resin. In this case the  
15 hydrocarbon resins have a very low molecular weight, too  
16 low in fact for the resins to be of any use on their own,  
17 and are difficult to mould. By mixing low molecular  
18 weight hydrocarbon resin with polystyrene, the stress  
19 limit of the polystyrene is reduced giving the material  
20 the characteristics described in the present Application.  
21 Preferably the low molecular weight resin will have a  $M_n$   
22 (number average molecular weight) such that it has less  
23 than 500 repeating units, and preferably less than 50  
24 repeating units.

25  
26 The following is an example of the material of the  
27 present invention.

28

#### 29 **Example 1**

30 In order to achieve a material with a stress limit of 24  
31 Mpa, a 50% mix of polymer and 50% resin is used, which  
32 achieves this stress limit. Typically the polymer could  
33 be crystal polystyrene such as Polystyrol™ 143E, and  
34 resin Plastolyn™ 240.

1

2 **Example 2**

3 In order to achieve a material with a stress limit of 34  
4 Mpa, a 60% mix of polymer and 40% resin is used, which  
5 achieves this stress limit. Typically the polymer could  
6 be crystal polystyrene such as Polystyrol™ 143E, and  
7 resin Plastolyn™ 240.

8

9 A container having improved safety characteristics can be  
10 manufactured from the material comprised of an amorphous  
11 thermoplastic polymer and one or more resins. The resins  
12 are aromatic hydrocarbon resins and are selected from a  
13 group consisting of Norsolene™, Krystalex™, Plastolyn  
14™, Endex™, Sokorez™, Arkon™, Piccolastic™ and  
15 Piccotex™, and in particular Norsolene W90™, Norsolene  
16 W100™, Norsolene W110™, Kristalex F85™, Kristalex F100  
17™, Kristalex F115™, Plastolyn 240™, Plastolyn 290™,  
18 Endex 155™, Piccolastic D125™, Sukorez 100™, Sukorez  
19 120™, Arkon P100™, Arkon P125™, Arkon P140™, Piccotex  
20 75™, Piccotex 100™ or Piccotex 120™. In a particular  
21 embodiment the one or more low molecular weight resins  
22 are C9 hydrocarbon resins with an  $\overline{M}_n$  (number average  
23 molecular weight) such that it has less than 500  
24 repeating units and preferably less than 50 repeating  
25 units. The resin or resins chosen will be selected on  
26 compatibility with the chosen polymer.

27

28 Low molecular weight in resins is a function of the  
29 length of the chains in the resin. In this case the  
30 hydrocarbon resins have a very low molecular weight, too  
31 low in fact for the resins to be of any use as a  
32 structural plastics material on their own, and are  
33 difficult to mould. By mixing low molecular weight  
34 hydrocarbon resin with polystyrene, the stress limit of

1 the polystyrene is reduced giving the material the  
2 characteristics described in the present Application.

3  
4 The amorphous thermoplastic polymer is chosen from the  
5 group consisting of polystyrene (PS, styrene-  
6 acrylonitrile co-polymer (SAN), linear polyesters and co-  
7 polyesters and polycarbonate (PC). These can be mixed,  
8 blended or polymerised with the one or more low molecular  
9 weight resins. UV inhibitors, dyes, antioxidants, flow  
10 modifiers, colour pigments and brighteners can also be  
11 added to change or adapt the appearance of the container.

12  
13 The container herein described has many characteristics  
14 similar to an ordinary glass bottle - i.e. clarity,  
15 rigidity and brittleness. However when broken, the  
16 bottle shatters into fragments which are harmless and  
17 cannot be used to cut or pierce human skin.

18  
19 The material used to manufacture the container is  
20 fundamentally a blend of a rigid and normally brittle  
21 amorphous thermoplastic with a glass transition  
22 temperature  $T_g$  at least  $50^\circ \text{C}$  above ambient and one or  
23 more compatible low molecular weight resins. A rigid and  
24 normally brittle amorphous thermoplastic polymer is  
25 blended with one or more low molecular weight resins  
26 which have a  $\overline{M}_n$  (number average molecular weight) such  
27 that the resin has less than 500 repeating units,  
28 preferably less than 50 repeating units. The one or more  
29 low molecular weight resins have a weight average  
30 molecular weight of 6050 or below. The material is, by  
31 design, manufactured to break between 11 and  $60 \text{ Nmm}^{-2}$ .

32  
33 The material can be heated and made into the desired  
34 shape of the container, i.e. a bottle, glass or tumbler,

1 by any suitable technique known to the art e.g. injection  
2 moulding, extrusion blow moulding or pre-form injection  
3 blow moulding techniques.

4  
5 The container may be manufactured from one or more layers  
6 of the material. More than one layer may be used to  
7 provide improved oxygen barrier characteristics.  
8 Alternatively the container may be coated with an oxygen  
9 barrier. Conventional coating technologies can be broadly  
10 divided into two categories. The first are those that  
11 use vacuum or plasma routes to deposit very thin films of  
12 materials, such as carbon or silica, onto the surface of  
13 the article being coated. The second, rely on the  
14 atomised spraying of liquid organic materials onto the  
15 external surfaces of the bottle. Ideally all coating  
16 materials must not interfere with the economics of  
17 recycling, nor detract from the bottle's appearance, but  
18 a significant further consideration with thin film  
19 internal deposits is the need for the materials to be  
20 approved for food contact.

21  
22 As the container described herein is manufactured from  
23 the material at lower processing materials than  
24 conventional plastics, barriers which are not usually  
25 suitable for this purpose can be used. For example the  
26 container can be coated in Barex™ (acrylonitrile-methyl  
27 acrylate copolymer), and in particular Barex™ 210 or  
28 Barex™ 218, which has high oxygen barrier properties.  
29 This can be achieved either by overmoulding, spraying or  
30 co-injection techniques. The barrier could alternatively  
31 be acrylonitrile-methyl acrylate copolymer, ethylene  
32 vinyl alcohol (EVOH) or nylon MXD6. The barrier could be  
33 provided on the inside or outside of the container.

34

1 Oxygen scavengers such as all polyester Amosorb 3000 or  
2 X-312 scavenger may be used. These Oxygen scavenging  
3 materials can be incorporated into the material of the  
4 container to react with the gas before it reaches the  
5 contents. Amosorb 3000 or X-312 scavenger have particular  
6 application when the barrier selected is MXD6 nylon. With  
7 these types of active oxygen scavenging packages, shelf  
8 life performance is determined solely by the rate of  
9 carbonation loss and CO<sub>2</sub> loss is reduced by the presence  
10 of the MXD6 as a physical barrier. A scavenger of MXD6  
11 with metal catalysed oxygen reduction chemistry may also  
12 be used (Oxbar). This system reacts very quickly with  
13 oxygen in the container and has a high oxygen capacity,  
14 ensuring a long active life.

15  
16 The container may also have an inorganic coating such as  
17 amorphous carbon. This can be sprayed onto the surface  
18 of the container being coated. The inorganic coating can  
19 be applied either to the inside or outside of the bottle  
20 after blowing. Plasma-applied coatings, using carbon or  
21 silicon, which have recently been developed, may be used.  
22 The Sidel Actis™ and Kirin DLC™ coating technologies can  
23 be used produce a thin layer of amorphous carbon,  
24 typically 100 to 200nm thick, on the inside surface of  
25 the container. This is deposited from a high-energy  
26 plasma of acetylene gas within a high vacuum environment.  
27 The coating provides an excellent barrier to both O<sub>2</sub> and  
28 CO<sub>2</sub>, and, because it is on the inside of the container,  
29 prevents the O<sub>2</sub> dissolved in the material of the container  
30 from migrating into the contents of the container during  
31 the first few weeks of storage.

32  
33 Because the deposited layers are fundamentally brittle,  
34 they have to be extremely thin in order not to flake off

1 under container stresses, caused by bottle expansion and  
2 creep when the bottle is filled, and under pressure from  
3 the contents. Other factors include damage and scuffing  
4 due to bottle handling, but these clearly do not affect  
5 the integrity of the coating if it is on the inside. The  
6 barrier performance improvements of carbon coatings are  
7 similar to those achieved by organic coatings, again  
8 giving a longer potential retail shelf life of around  
9 nine months.

10

11 Silica technologies such as Glaskin and BestPet can also  
12 be used. These rely on the application of a  $\text{SiO}_x$  vacuum  
13 plasma coating, to give a barrier layer between 40 and  
14 60nm thick. While the Glaskin process applies the glass  
15 clear coating to the inside of the bottle, the BestPet  
16 technique applies it to the outside.

17

18 As an alternative an organic coating may be used.  
19 External organic coatings have been known and used in the  
20 industry since the early 1980s. In the mid 1990s, barrier  
21 coating solutions based on two component epoxyamine  
22 chemistry (Bairocade) were developed, first to lengthen  
23 the shelf life of the smaller soft drink sizes in hotter  
24 climates, and then for beer. These provide a  
25 transparent, glossy, external spray coating which is an  
26 excellent barrier to migration of  $\text{CO}_2$  and  $\text{O}_2$ , and is  
27 unaffected by humidity. The low temperature thermoset  
28 cure provides a tough film, robust to filling and  
29 handling conditions.

30

31 Typically the coating will be applied to the container at  
32 thicknesses between  $6\mu\text{m}$  and  $10\mu\text{m}$ , and allow the use of  
33 standard resins and preforms with existing injection and  
34 blow moulding equipment. The use of such coatings

1 provides a performance improvement which is around 19  
2 times better than an uncoated container and translates  
3 into a longer retail shelf life. The external organic  
4 coating may be PVDC two component epoxyamine.

5  
6 The alternative approach to improving the gas permeation  
7 properties of the container material is to manufacture it  
8 from multiple layers of the material. In other words,  
9 two or more layers of the container may be combined to  
10 act as an improved oxygen barrier. Final shape blowing  
11 produces a bottle with up to seven different polymer  
12 layers, which either act as a physical barrier to gas  
13 permeation, or are chemically active in scavenging oxygen  
14 from the material of the container and intercepting  
15 oxygen diffusing in from outside.

16  
17 The material herein described has an elevated glass  
18 transition temperature, which is much higher than the  
19 glass transition temperature of, for example, PET. PET  
20 has a glass transition temperature that is lower than the  
21 pasteurisation temperature used in the beer industry. As  
22 a result when PET is used in the manufacture of bottles,  
23 creep may occur during filling. In other words the  
24 material expands, which causes deformity of the bottle.  
25 This problem is eliminated using the material herein  
26 described as the glass transition temperature is above  
27 the pasteurisation temperature used during filling.

28  
29 Furthermore, bottles made from PET are generally filled  
30 using flash pasteurisation, as opposed to full  
31 pasteurisation, which the industry prefers. Full  
32 pasteurisation is generally more efficient which results  
33 in a longer shelf life for the product. However full  
34 pasteurisation is not generally used with PET materials.

1 A particular advantage of the material herein described  
2 is that because it has an elevated glass transition  
3 temperature, it can withstand full pasteurisation.  
4

5 It has been discovered that using the above described  
6 material a container such as a bottle, glass or tumbler  
7 can be manufactured which does not cut, puncture or  
8 otherwise damage human skin or tissue when broken. In  
9 other words, the container will shatter into harmless  
10 fragments, shards or pieces when broken.  
11

12 A particular advantage of the container described herein,  
13 lies in the fact that even though it does not shatter  
14 into dangerous fragment when broken, it has a similar  
15 quality feel as glass, and has improved aesthetic  
16 qualities over existing plastics such as PET. The  
17 material herein described for use in manufacturing a  
18 container, is relatively light and glass-like to touch  
19 and as it is a polymer is can be processed, for example  
20 by including oxygen barriers during production.

21 Importantly, the material is thicker than an equivalent  
22 PET bottle so has a more glass-like feel but can be  
23 manufactured into containers without an increase in cost.  
24

25 Potential uses of the container are not limited. For  
26 example, the container may be used for beer, carbonated  
27 soft drinks, oxygen sensitive juices, beverages or milk  
28

#### 29 Example 1

30

31 An 85% mix of polystyrene polymer and 15% resin is used  
32 to manufacture a bottle with improved safety  
33 characteristics. The 15% resin maybe comprised of a  
34 single resin selected from the group consisting of



1 Norsolene<sup>TM</sup>, Krystalex<sup>TM</sup>, Plastolyn<sup>TM</sup>, Endex<sup>TM</sup>, Sokorez  
2 <sup>TM</sup>, Arkon<sup>TM</sup>, Piccolastic<sup>TM</sup> and Piccotex<sup>TM</sup>, or may be a  
3 combination of two or more of the above. Plastolyn<sup>TM</sup> is  
4 particularly suitable for this purpose. The resin or  
5 resins are selected to achieve a desired molecular weight  
6 range.

7  
8 Further modifications and improvements may be added  
9 without departing from the scope of the invention herein  
10 intended.

11  
12  
13